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Clean cooking interventions: Towards user-centred contexts of use design

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ABSTRACT

Clean cookstove interventions largely fail to achieve their stated aims. In our view, the underlying flaw of many cooking interventions is a systemic lack of attention to users' rank ordering of product features and contexts of use during the product design process. Drawing on examples of cookstove and product design, together with our experience in cookstove design, research and product standards development, we offer four suggestions for improving cookstove interventions. First, consider the benefits of incremental changes. Second, do not define the problem or the solution too quickly. Third, make no assumptions about how well you know the end user. Fourth, bring users, donors, manufacturers and implementing agencies into the design process. We conclude with a call for an inclusive approach to designing cookstove interventions that is centred around the lived experiences of users and rooted in context-specific knowledge.

Public health experts agree that “dirty cooking” over open fires or primitive cooking stoves is an ever-present health hazard in low income contexts. Although many organizations prioritize the supply of modern stoves and fuels, initiatives focused on cooking hardware have largely failed to achieve their stated aims. All told, as many as 3 billion people still cook in conditions that contribute to chronic illnesses [1,2]. Critics might say that shortfalls are natural to well-intended efforts to ameliorate the negative consequences of cooking, but stove experts tend to adhere to one of three schools of thought as to why cookstove interventions go so consistently wrong [3]. Some experts blame the problems on the cook, citing their inability or unwillingness to change cooking habits (the behaviour assumption). Another group conclude that better technologies are needed (the engineering assumption). Finally, implementing agencies are sometimes accused of inappropriate product selection criteria, incomplete user training or inadequate attention to creating a sustainable value chain (the intervention assumption).

These assumptions connect with problems about cookstove interventions that researchers have known for decades: the performance of “improved” cookstoves is often overrated; new cookstove designs too often require cumbersome lifestyle changes in order to realize better efficiency and health outcomes; misalignment between the goals of cookstove advocates and needs of target populations are common and rarely adequately addressed; cookstove advocates underestimate the value of traditional cookstoves, particularly benefits unrelated to fuel

efficiency such as accommodating different pot sizes, multi-fuel capacity, space heating, and smoke being an insect repellent; and finally, significant problems with the implementation of stove substitution interventions [1,2].

Numerous initiatives have proposed that the problems of stove and fuel replacement interventions can be addressed with new designs, testing protocols, metrics or better information [1,2,4,5]; in our view these are necessary but not sufficient to realize better intervention outcomes. After years of involvement with designing, researching and producing product standards for cooking appliances, we believe that a better combination of behaviour, engineering and intervention perspectives is required to overcome the underlying flaw for why cookstove interventions have failed to stimulate broad adoption. This underlying flaw relates to a systemic lack of attention to users' rank ordering of product features and contexts of use – adequately captured using appropriate metrics – during the product design process. We believe that an inclusive, user-centred, contexts of use approach to cookstove intervention design offers an opportunity to perceive, comprehend, account and then correct for this fundamental flaw. Such an approach, we believe, is a path to improving future clean cooking initiatives, regardless of whether their ultimate goal is incremental design modifications to existing stove technologies or the introduction of radically different designs or new fuels.

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1. The problem-solution problem

At first glance, the persistence of “dirty cooking” globally and the obvious need for “improved stoves” appears to be a straightforward supply problem with a specification and procurement solution. It is obvious that smoke from open fires and rudimentary stoves harm people’s respiratory health and even shortens their lives, particularly for those most exposed. Donors, in particular, like to approach problems with simplistic, technical solutions: People do not have efficient stoves? Give them a better model! Problem solved, credit claimed. To use Christensen’s innovation terminology, the donors, engineers and international agencies define “the problem,” “the task,” and “the solution” as being an “improved” or “clean burning” stove [4,5].

However, better cooking is a far more complicated process. First, define “better.” Often, the fuel that gives the “best performance” according to designers is not the fuel users have or prefer to use [6]. Second, it is always tempting to present a strong narrative to make an intervention more compelling. For example, some organizations promoted metal stoves and solar cookers to displaced women in Darfur as being “better” than inexpensive, locally designed, built-in-place mud stoves. Based on incomplete narratives of violence and anecdotal cases, it was assumed that fuel efficiency gains from using metal stoves and solar cookers would translate into reduced risks of sexual violence for women who travelled long distances to gather firewood outside “the relative safety of the camps”. A fundamental flaw in this theory is the assumption that it is safer for women *inside* the camps than *outside*, which is rarely the case. Further, the search for firewood is only one of many reasons for leaving the camps. Finally, even if a stove *used* less fuel women might still travel long distances to *collect* firewood because fuel is a saleable commodity [7,8].

More recent research suggests that women in Darfur’s camps do prefer metal cookstoves over mud stoves because they can fuel them with charcoal, not the wood for which they were designed. Using charcoal, a completely different fuel, vitiates any performance or climate rating based on wood. In Darfur’s camps, charcoal is cheaper than wood, more readily available, and appreciated as “cleaner” because the stove emits less smoke [9].

Quite against the donor’s expectations, it was discovered that women used the modern metal stove in “novel” ways including inverting it and using the stove bottom as a fire pit with the upturned legs serving as pot or cooking tray supports. This orientation for cooking special meals is less fuel inefficient and possibly more dangerous than cooking over an open fire. Hence, though donors and implementing agencies felt their interventions had addressed “the problem,” the all-metal “wood-burning” stoves they promoted failed to make women safer from violence and embodied a testing blind spot in terms of fuel consumption, health, and the environmental consequences of cooking with charcoal [9].

This situation is by no means unusual. Over and over, when the problem boundary is inappropriately or prematurely defined, agencies have selected replacement stoves that confuse designer and donor *preconceptions* of recipients’ needs with what recipients actually value, want or need [10]. This can be described as an *institutionalized pattern of development*: engineers develop and lab-test objectively superior stoves from some decontextualized perspective, often inventing some new or better combustion system, and offer it to stove project implementers as a quick path to market. Projects select the new and exciting technology, unproven in the field, on the basis of technical parameters and with the assumption that “people will adapt to the technology.” This could be why so few improved cooking stove interventions actually achieve their stated social and technical objectives [1,2].

2. The lure of the magical stove

As philosopher Rom Harré observes, “Material things have magic powers only in the contexts of the narratives in which they are

embedded” [11]. This is certainly true for improved cookstoves, which have proven much better at captivating the imagination of advocates, donors and engineers than the billions of people living in low income households with kitchen-related problems.

All too often, well-meaning donors and implementing agencies try to develop the best of all possible cookstoves by focusing on performance metrics that reflect their own priorities and ideas of excellence, not those of the cooks. With no one challenging the problem definition, the solution writes itself. Humanitarian agencies are geared towards “dissemination” and therefore organize their work around procurement, coordination and distribution. All three tasks are aspects of “marketing.” It is important to ask: Can the deep, contextually-rooted problems faced by cooks be solved by improving on these tasks? What problems do they solve? Whose problems are these?

The problems faced by cooks vary by culture, geography, season, fuel type, local practices and general awareness. For example, a recent Nigerian study on the use of ethanol stoves underwritten by Royal Dutch Shell yielded an unexpected result. Researchers compared a group of cooks who were given clean-burning ethanol stoves plus training on healthy and safe cooking, with a control group who were given the same training only. The researchers found that the performance of the group who received the ethanol stoves improved substantially, but so did that of the control group. This suggests that in Nigeria at least, education and training may be a more significant and cost-effective public health policy intervention for improving health outcomes *at scale* compared with the marketing of new stoves and fuels [12].

The need to consider context is true for all kinds of interventions. Microfinance, for example, encountered cultural and regulatory differences when translated from Bangladesh, where it was popularized by BRAC and the Grameen Bank, to India. With fewer informal restrictions in India, loans were soon coupled with new farming approaches such as the increased use of biotech seeds and fertilizer. That combination introduced uncertain hopes and enduring vulnerabilities that devastated many farming communities [13,14].

The *mPesa* mobile-based financial system, developed and wildly successful in Kenya, flopped in South Africa. Backers had not understood that the essence of Kenyan success was the lack of access to an advanced banking infrastructure, which South Africa enjoyed. Further, South Africans had much less need for cross-country remittances due to different culturally-rooted patterns of economic dependence and support [15].

In these and many other cases, overlooking the end-user’s cultural, economic and technological contexts is a significant blind spot for those engineers, designers and donors seeking a magic device or panacea. This includes promoting a technology that might be useful in one setting as *the* solution elsewhere. When it comes to gendered interventions, conceptual design errors are not only made when the end-user is on the other side of the world – they are also made when the user sits across the table. The lack of consideration to women’s needs in design has made life more difficult and dangerous for half the world’s population; this is just as true for cookstoves as it is for cars, smartphones, cities and medical care [16,17].

3. Keeping sight from the blind

Lack of end-user research is a significant source of unawareness in humanitarian programming as efforts to improve deliverables, processes and outcomes are rarely the focus of donor-directed monitoring and evaluation. A 2015 paper funded by the UK’s Department for International Development found that funding for humanitarian innovation was “breathtakingly low,” budgeted at a mere \$37 million a year, or 0.27 percent of total global humanitarian spending [18]. At present, the work of refining donors’ understandings of problems, whose they are, and what solutions might be appropriate does not appear within the scope of most donor-funded implementing agencies.

This is a structural blight on the humanitarian landscape.

Framing interventions on the precise needs of target beneficiaries would confer an important advantage for implementation agents: a promoted solution is much more likely to resolve or even ameliorate the problem it seeks to address. For example, one of the most successful heating and cooking stove projects we know of did just that, beginning with the observation that the goal of the donors – a dramatic reduction in domestic heating stove emissions – was quite different from that of users who universally sought a major reduction in fuel consumption. The project, which focused on air quality management in Ulaanbaatar, Mongolia, used this approach: an industrial designer with experience in stove design, guided by a social anthropologist with experience in stove dissemination, studied how, why and under what cultural assumptions people used stoves *in situ*. Many key cultural practices were revealed. For instance, after receiving new stoves most families choose to keep their existing working stove rather than sell it, as is the case in many contexts. This is because of a belief that the *golomt* – the spirit of the fire that dwelt in the stove – had developed a beneficial relationship with that particular family; because the stove's *golomt* might not work harmoniously with a different family, only 5% of displaced stoves ever reach the resale market. The popularity of this belief essentially eliminated the possibility for the lowest-cost option of recycling: purchasing, upgrading and reselling stoves with greatly improved performance. Almost no one would accept to have a pre-owned stove in the house, even if provided for free.

With this and a hundred other gleanings of knowledge, it was possible to design modifications, identify appropriate performance metrics, and create a fuelling and operating sequence that was representative of a typical pattern of use. A key element of this was to identify emission patterns in the city air which were ultimately traced to stove operating behaviour, rather than something inherent in the properties of the fuel (i.e., coal). Lim et al., determined to monitor the impact of project-promoted top-lit updraft gasifier stoves on indoor air quality, concluded that the stove replacement project created no statistically significant improvement [19]. It was not an indoor air quality project, but an ambient air pollution mitigation intervention that between 2011 and 2015 lowered ambient air pollution in poor neighbourhoods by 65%.

This is an example of how failing to understand the broader context led researchers to attain the correct answers for the wrong question. Indoor air pollution originates largely outside the home. In this case, researchers were only measuring the outdoor air's impact on indoor air pollution because the stove exhaust necessarily pulls outdoor air into the home. Moreover, at the same time the stoves were being replaced, the government both changed the fuel supply to a subsidized lower quality fuel with higher emissions and promoted household insulation with the effect of reducing indoor air turnover. As is the case in other settings, macro policy actions can lead to unexpected and counter-intuitive outcomes [20].

Producing transformative products that are more likely to be taken up by the market at scale requires product selection protocols capable of meeting all user and project needs. In conventional product selection processes, donors often select from pre-existing products that are unlikely to have been developed with target beneficiaries or their lived experiences in mind. Applying contextual and culturally-sensitive ethnographic insights together with modern science and design engineering goes much farther than merely selecting from products already on the market. The multi-producer, multi-product, multi-donor intervention resulting in the dramatic reduction in air pollution in Ulaanbaatar over only 4 years was a selection success but not a product development success. The improvement in air quality was achieved without changing the primary fuel (i.e., coal), with an increase in population of 30%, and a sextupling of the number of vehicles. But the story does not end here.

A product idea that arose in Ulaanbaatar in 2010 did not get to the mass production stage at that time. However, in 2016 it was revived in Tajikistan and Kyrgyzstan, then reintroduced to Ulaanbaatar. It

happens that the culture of rural highland people in these three regions is quite similar, as is the heating requirement, cooking style and fuels available. Having already achieved the ambient air pollution-related goal, this time the stove researchers concentrated on zero indoor emissions, ease of fabrication, and low attention demand. This led to a novel combustion system suited to local manufacturing: a hopper-loaded crossdraft stove that isolates refuelling behaviour from what happens in the combustor chamber. The result was a radical improvement in the combustion of lignite (wet, high volatile coal) to the point that when operating normally, particulate matter suspended in the air entering the stove was removed by the fire [21].

The research and design team did so by separating specific user behaviours that disrupted the burn quality during the loading of fuel. This attention to behaviour-induced emissions is not typically incorporated into technical emission-centric goals. It was a high resolution air quality time series analysis that confirmed why there was such a poor correlation between the mass of fuel burned per day and Ulaanbaatar's ambient air quality: almost all domestic stove emissions arose during ignition and refuelling, not fuel burning. The research focus turned to limiting emissions during ignition and eliminating it when refuelling. It must be said that no donor organization imagined that a fundamental innovation in small-scale coal combustion technology was possible. As such, coal-burning stove innovations are rarely sought. Most donors believe the only solution is modern fuel substitution, perhaps because this is how air quality improvements in Europe have been realized [22]. No one expected that smoke produced by burning raw coal could be reduced by more than 99% without changing the fuel. The result – the stove models KG4.4 and MN4.2 and their water heating analogues – were unlike anything seen before in the small stove sector [23,24]. With enhanced cooking efficiency and one-touch controllable firepower, the cooking needs are provided with much greater convenience [21]. Moreover, the design burns the same fuel with a tiny fraction of the smoke emissions. Since 2018, these designs have been adapted in six other countries from Russia to South Africa, with one Polish water-heating version having obtained EN 303-5:2012 certification in 2019 [25]. Successes like these demonstrate the necessity of acquiring, far beyond the requisite technical design skillset, a comprehensive understanding of how users relate to stoves in a particular setting; designers who understand this are able to develop solutions acceptable to both users and fabricators while still servicing donor and project goals.

4. User-centred contexts of use design

The risks of solving the wrong problem can be dramatically reduced when donors, designers, and implementing agencies spend more time getting to understand the lives and aspirations of the people they want to help. This requires a deep appreciation for the richness and complexity of people's values, needs, wants and lived experiences, as well as their historical, environmental and cultural contexts [9].

It goes without saying that for-profit businesses often run into similar problems when marketing innovations. The difference between businesses and development or humanitarian agencies, perhaps, is that the consequences of misunderstanding end users are often more dire and the margin for error of doing so ultimately much narrower. So, how do cookstove advocates, designers, distributors, donors, producers and sellers avoid these kinds of mistakes? We suggest four ways that can help embed users and their contexts of use in design and innovation processes.

First, consider the benefits of incremental changes. In our view, it is sensible to start with what is already accepted and try incremental improvements from time to time. This is the informal sector's approach to stove markets, where the vast majority of cooking stoves are made. We recognize that this can be challenging for donors and engineers working in settings where simple, inexpensive stoves are those most accepted by the local population. For instance, and similar to the

forementioned case of Darfur, Khandelwala et al. note how purveyors of modern cooking stoves in India pursued a singular focus on replacing traditional, hand-made mud stoves with engineered metal stoves – a process involving the demonization of local, low-cost, culturally accepted designs as being “wasteful, unhealthy, dirty and obsolete” [1]. Such occurrences are unfortunately all too common. Incremental design changes allow for gradual transitions, design experimentation, and greater latitude for participation by stakeholders in existing cookstove and fuel value chains. Stoves based on incremental modification may also support greater household-level resilience in relation to seasonal fluctuations in cooking needs as well as food and fuel availability [26]. From our experience, we have observed three distinct approaches to incremental design: (a) user-dominated incremental design, where local entrepreneurs, artisans or users incorporate innovations into existing products and technologies; (b) techno-centric incremental design, where engineers and emissions scientists provide (often imported) design modifications to which users are expected to adapt; and (c) an inclusive and collaborative approach involving users together with social anthropologists, inventors, engineers and air quality experts. While the first two approaches often do lead to design improvements, the latter interdisciplinary approach is more likely to lead to polymorphic modifications with radically improved benefits [21,27].

Second, do not define the problem or the solution too quickly. Too often, stove interventions begin with a rigid understanding of the so-called problem to be “solved.” Preconception problems lend themselves to off-the-shelf techno-solutions that may reflect the vision, technical expertise and implementing capabilities of donors and implementing agencies – but not the needs or interests of users. This is because people are often trapped in an “egocentric empathy gap” whereby they project their own preferences and desires onto others [28]. It becomes even more problematic when inappropriate or defectively calculated “performance metrics” are used to evaluate a solution. Rethinking problems and their actionable solutions begins with the simple reframing of the questions advocates and designers ask, both of themselves and of users. Fully understanding a problem should precede the selection of appropriate metrics. For instance, Abdelnour and Saeed began their critique of the myth that improved cookstoves prevent sexual violence by asking: “How is sexual violence understood such that cookstoves are thought to be a logical solution?” [5]. Embracing and experimenting with different framings of questions that interrogate generally-accepted understandings of problems and solutions can lead to new insights informing cookstove design and delivery.

Third, make no assumptions about how well you know the end user. In any narrative, especially those where emotion runs high – as is often the case with refugee camps, violence and extreme poverty – it is easy to fill in knowledge blanks with images conveyed by media as well as humanitarian and political advocacy. Too often these are actually placeholders or intermediary interpretations that filter the reality of the user’s wants, needs and values. It is essential that assumptions about cooking and behaviours are replaced with in-depth knowledge of users’ lived experiences [26,28]. Comprehending these lived experiences requires knowledge of stove operating practices and preferences, paying attention to seasonal and market fluctuations, and attention to how these can evolve over time [1,9,26]. Intimate knowledge of lived experiences can be attained through in-depth qualitative enquiry, such as those advocated as part of the “ethnographic turn” in household energy research [28,29,30]. It is a given that the “ethnographic expert combustion engineer industrial designer” does not exist; hence, rich qualitative context-specific knowledge requires interdisciplinary teams. Once attained, in-depth user and contextual knowledge may help clean cooking advocates resist the lure of the magic object by rejecting oversimplified problem definitions, pre-packaged dreams and, ergo, the mirage of magic solutions [5,11].

Fourth, bring users, donors, manufacturers and implementing agencies into the design process. Turning the design process into a shared investigative journey is one way to open lines of communication

with both donors and users while progressively reducing the risk of implementing something based on a misunderstanding [31]. Further, enrolling a greater diversity of stakeholders – users, craftspeople, engineers, entrepreneurs, designers, health scientists, implementers, researchers and policymakers – in an inclusive ideation process will help to advance shared understandings of both problems and solutions. It goes without saying, stakeholder ideation processes should precede product selection, development and dissemination [27,28]. By creating a consultative process for all stakeholders, communication lines are kept open and more ownership is created. At the same time, everyone is held responsible for developing an innovation that focuses on the verified needs, wants and context of the eventual user [32].

Technology by itself seldom drives all-positive change and is invariably accompanied by cultural baggage [33]. In a technology-focused age, we often forget that simple low-tech innovations might actually be more impactful in effectively addressing complex societal challenges [34]. Successful innovations require intimate understanding of the host culture as well as a string of technical issues and solutions. It is about co-creation [28,32]. To that end, the most successful cooking stove solutions we know of are modern technologies designed, tested and certified by users together with teams of engineers and social scientists with a deep knowledge of local customs and conditions, and an ability to continually centre the lived experiences, needs and aspirations of users throughout the design process [9]. These may very well lead to incremental changes capable of attaining drastically improved performance and adoption. Alternatively, they may provide better insights for advancing radically different designs that are intimately tuned to the specific needs of users and better suited for their particular contexts of use.

Declaration of Competing Interest

Crispin Pemberton-Pigott worked as part of the World Bank team on the mentioned Mongolian and Kyrgyzstan projects in the capacity of technical adviser and product design trainer.

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